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The Spawning of the Plaice
(*Pleuronectes platessa*)
in the Irish Sea

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The Spawning of the Plaice (*Pleuronectes platessa*) in the Irish Sea

I. INTRODUCTION

WHILE the spawning of the plaice in the North Sea has been the subject of extensive and intensive investigation over a number of years (Buchanan-Wollaston, 1914, 1923 and 1926; Simpson, 1959), knowledge of the spawning of the plaice in the Irish Sea has remained very incomplete.

Scott (1913, 1914 and 1915) reported on the occurrences of fish eggs in plankton hauls made with tow-nets in various parts of the Irish Sea over a number of years and found plaice eggs to occur round the south-western coast of the Isle of Man between early February and mid-April; in small numbers at several scattered positions between the Lancashire coast, the Isle of Man and the Solway Firth from early February to mid-April; and in coastal waters in central Cardigan Bay in December and January.

Johnstone, Birtwistle and Smith (1922) summarised the then existing knowledge on the plaice and plaice fishery of the Irish Sea and wrote, 'We think there are two sources of the plaice eggs that are found in the Irish Sea: (1) somewhere to the S.W. in St. George's Channel, and (2) the grounds near the entrance of the Solway Firth.' (loc. cit. p. 89). That spawning occurred towards the entrance of the Solway Firth had also been shown by the catching of spawning female plaice in an area between St. Bees Head (Cumberland) and the Isle of Man in January to April, 1920. However, Johnstone *et al.* considered that the spawning somewhere in the neighbourhood of the St. George's Channel was in fact the more important, and that this spawning produced the eggs which were found in Cardigan Bay and northwards to the Lancashire coast, the eggs being transported to the north and east by the residual drift.

Little was added to this very incomplete picture during the following 30 years. It was therefore an event of no little interest when it was planned to take the research ship SIR LANCELOT to the Irish Sea in 1953 in order to determine the time and position of spawning of the Irish Sea plaice by the methods that had proved so successful in the North Sea.

Unfortunately the ship was available only until the end of March so that it would not be possible to study the later part of the spawning which Scott had shown to continue throughout most of April and possibly into May. However, the project was considered well worth while if the time of the start of spawning and the positions and relative importance of the main spawning areas could be established.

In addition to determining the time and position of spawning by systematic quantitative plaice-egg surveys, the size and age-composition of the spawning fish were to be studied by trawling in the spawning areas thus located. Mature female plaice about to spawn were also to be obtained during this trawling in order to study the fecundity of the Irish Sea plaice.

II. THE TIME AND POSITION OF SPAWNING

(a) METHODS

THE spawning areas were located by determining the distribution of recently-spawned plaice eggs in the plankton. The lack of information on possible spawning areas made it

necessary to work as extensive surveys, and as many coverages of the area, as the available time permitted.

Four surveys were made on the following dates:

1. Jan. 23rd–Feb. 3rd (Irish Coast and south of Anglesey, Jan. 23rd–27th; between North Wales and Scotland, Feb. 1st–3rd).
2. Feb. 9th–17th.
3. Mar. 7th–14th.
4. Mar. 20th–28th.

At each station, three vertical hauls were made with the Helgoland larva net from 2 fathoms above the bottom to the surface, hauling at a mean speed of 1 metre per 3 seconds. The net was hauled by means of a 275 lb. counterweight to keep a constant hauling strain on the net in spite of the rolling of the ship (Buchanan-Wollaston, 1914; Simpson, 1959).

Immediately following the working of each station, the number of plaice eggs caught at that station was determined by the macroscopic examination of the sample on the silk and the number plotted on a track-chart. In this way, the best use of the ship's time could be made by continuing to work stations round a patch of eggs until its limits were established, while avoiding making stations where it could be seen that eggs were very unlikely to be present. This was particularly important once it was found that the eggs were almost completely limited to the coastal or relatively shallow areas, for it permitted the reduction of the number of stations in the deep water channel.

The macroscopic examination of the catch was straightforward as the standing crop of plankton was typically small, and because there was only one other fish egg occurring in the area with which the large egg of the plaice could be confused, i.e. the eggs of the Long Rough Dab (*Drepanopsetta platessoides*) and these were distinguished by their iridescent colouring and large perivitelline space, both of which characters were visible without a microscope.

At a later date, in the laboratory, the plaice eggs were examined under low-power magnification and classified into five stages of development as used by Buchanan-Wollaston (1926), but most readily referable to Apstein's (1909) drawings of his 25 stages. The limits of Buchanan-Wollaston's five groups are given in Table 1.

Table 1: *The limits of the five developmental stages into which the plaice eggs were classified*

<i>Buchanan-Wollaston's groups</i>	<i>Apstein's stages</i>	<i>Limits of groups</i>
		Egg spawned
I	1–6	
II	7–11	Blastopore lip forming equator to yolk
III	12–16	Cowper's vesicle disappearing
IV	17–20	Embryo extends $\frac{3}{4}$ -way round egg
V	20–25	Tip of tail just reaches snout
		Hatching

The details of all stations where one or more plaice eggs were caught, are given in full in Appendix I. All place-names referred to in the text are shown on Fig. 1 and the positions of all stations worked on each survey are marked on Figs. 1–4. On these charts are also contoured the distribution of group I eggs and groups IV+V eggs per 3 hauls of the Helgoland larva net, i.e. the actual number of eggs caught, unscaled. Contours are drawn at 1, 5, 15, 25 and 35 eggs in three hauls.

In fine weather, with wind and sea of Beaufort force 3 or less, the ship drifted only a small amount during the hauls and the net came up vertically or nearly so, and thus the catch per three hauls will be approximately the number of eggs below 4.75 m². of sea surface.

In increasingly bad weather, the drift of the ship increased and the net came up at an increasing angle, filtering more water, thus giving an overestimate of the number of eggs present below a unit of water-surface. It can be seen from Appendix I that on the first survey, half the stations at which plaice eggs were found were worked under conditions with wind and sea at or below force 3, while half were done with wind and sea at force 4, with one station at wind force 4/5 and sea 5. On the second survey, only those stations north of 54° 04'N. were done in wind of over force 3. On the third survey, one station where plaice eggs were caught was worked with wind or sea over force 3, and on the fourth survey, four stations.

The time taken for plaice eggs to pass through the different stages of development depends on the temperature of the water. As the temperature varied considerably, the times taken for eggs to pass through the stages corresponding to group I and groups IV+V, and the times from half-way through group I to halfway through groups IV+V, have been calculated for the different areas (from Apstein's tables), and are given in Table 2.

Table 2: *Duration of group I and group IV+V egg-stages and the interval between the half-way stages of each phase at the mean sea-water surface temperature in each area on each survey*

Survey	Position	Temp. °C.	Duration of Group I (Days)	Duration of Group IV+V (Days)	Time taken from mid-group I to mid- group IV+V (Days)
1	I.O.M. - Cumberland	5.9	4.2	8.0	13.9
	Great Orme	5.9	4.2	8.0	13.9
	Cardigan Bay	6.2	4.1	7.8	13.2
	N. Cornwall	9.0	3.1	5.8	10.0
2	I.O.M. - Cumberland	5.2	4.6	8.9	15.1
	Great Orme	4.6	5.0	9.8	16.3
	Cardigan Bay	5.6	4.3	8.4	14.3
	N. Cornwall	8.0	3.4	6.4	11.0
3	I.O.M. - Cumberland	5.8	4.2	8.2	14.0
	Great Orme	5.8	4.2	8.2	14.0
	Cardigan Bay	6.6	3.8	7.5	12.8
	N. Cornwall	8.2	3.3	6.3	10.8
4	I.O.M. - Cumberland	6.4	4.0	7.7	13.0
	Great Orme	6.2	4.1	7.8	13.2
	Cardigan Bay	7.2	3.6	6.9	11.8
	N. Cornwall	7.3	3.6	6.8	11.7

On an average, the eggs of group I will have been about half as old as the times given in this table, i.e. about 2 days old, and they will therefore not have drifted far from the positions at which they had been spawned. From an examination of Figs. 1-4, it is evident that the spawning was limited to the shallower waters and that there was no evidence of any spawning in St. George's Channel. Although a few eggs were caught on the Irish side of the Irish Sea, the vast majority were found on the eastern side.

The spawning is seen to have been concentrated on four main areas which will be described in turn.

(b) NORTH CORNWALL

On the first survey three plaice eggs were caught at station 3, some nine miles west of Trevoze Head; one was in group I and two in group II. As no plaice eggs occurred in the two adjacent offshore stations, which were some ten miles west and north respectively of station 3, it was considered that spawning had only just started in this area.

On the second survey six stations gave plaice eggs, with 121 at station 77, lying only

some eight miles west of station 3 of the previous survey. The interval between the observations in this area on the two surveys was 25 days (Jan. 23rd to Feb. 17th). At the temperature of the sea-water at the time, 8–9°C, plaice eggs take only 16 days to develop from being laid to hatching, so it is certain that all the eggs caught on the second survey had been laid at least a week after the first survey had covered the area. There were also a few plaice larvae at station 77, one of which had the yolk resorbed. These could also have been produced from eggs laid on or after Jan. 23rd. However, it can not be ruled out altogether that more eggs had been spawned off the north coast of Cornwall just beyond the area sampled, by Jan. 23rd, than was indicated by the catch of three plaice eggs at the one station on that date.

On the third survey (Mar. 7–8th), fewer group I eggs were found east of Trevoze Head but some were caught at a new position just west of Lundy Island; while by Mar. 26–27th, on the fourth survey, although there were a few older eggs in both positions, the young eggs were now centred to the west of Lundy Island, showing that the centre of spawning had shifted some forty miles to the north. The number of group I eggs found on Mar. 26–27th was approximately the same as that on Mar. 7–8th, suggesting that spawning was likely to have continued at a low level at least into early April (see Figs. 1–4 and Appendix I).

(c) CARDIGAN BAY

Plaice eggs were caught at three stations in Cardigan Bay during the first survey (on Jan. 26th) and the presence of a number of group III eggs and a few group IV and V eggs showed that spawning had started here at least two weeks before.

The second and third surveys confirmed the position of this spawning area and showed it to be centred well inshore, the largest numbers of group I eggs being caught in 9–11 fathoms of water at the stations closest to the shore and within 4½ miles of the beach, some three miles south of Aberystwyth. Between the third survey (Mar. 10–11th) and the fourth survey (Mar. 21st–22nd), there was a striking change in the distribution of the young plaice eggs. Instead of being centred inshore, on the fourth survey they were most abundant in water of 18–20 fathoms in the mouth of the Bay, some 15–20 miles to the west of the previous centre.

Young eggs were most abundant on the second and fourth surveys, with considerably fewer on the third, showing that there had been a lessening in spawning during early March as compared with mid-February and late March. Spawning was clearly still active on Mar. 21st and 22nd and there is no evidence to show how much longer it would have gone on. Although stations were worked in Caernarvon Bay to the south of Anglesey on three surveys, group I plaice eggs were only caught at one station (on the third survey), indicating that while some spawning occurred in this bay, it was very limited.

(d) GREAT ORME

The presence of a discrete spawning area off the North Wales coast came as a considerable surprise, since there had never been any indication of it as a spawning area in past writings. On the first survey plaice eggs were found at two stations, with 9 group I eggs at the station five miles due north of Great Orme's Head. This number was probably some 30–40% too great, as the station was worked in a force 4 to 5 wind. On all four surveys, more young eggs were found on this station off Great Orme's Head than on the other stations in the area, with the exception of the third survey when the station twelve miles to the east had the same number (22) of group I eggs.

On the fourth survey, 42 group I eggs were caught at the station off the Great Orme in calm weather, the highest number of group I eggs caught at any station on the four surveys.

Only on the second survey were any group I eggs found at the stations off the north coast



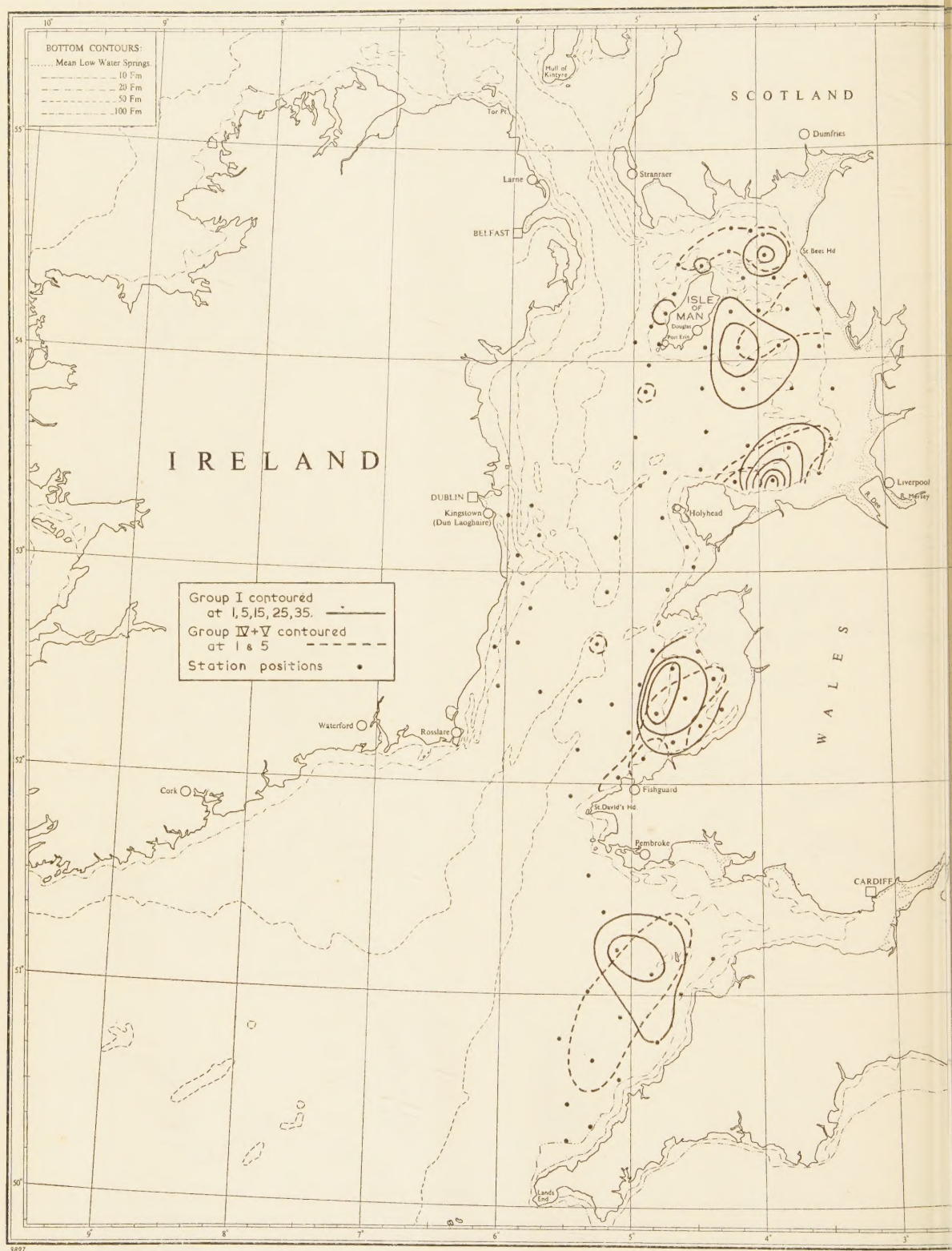
Fig. 1. *Distribution of plaice eggs on Survey 1, Jan. 23rd–Feb. 3rd, 1953.*



Fig. 2. Distribution of plaice eggs on Survey 2, Feb. 9-17th, 1953.

Drawn and Reproduced by Ordnance





Drawn and Reproduced by Ordnance

Fig. 4. Distribution of plaice eggs on Survey 4, Mar. 20-28th, 1953.



Drawn and Reproduced by Ordnance Survey 1953.

Fig. 5. The limits of the occurrences of Group I plaice eggs on the four surveys combined (continuous line) and the positions where most Group I eggs were found in each area (broken lines).

of Anglesey and all three taken were in Apstein's stages 4-6, while the group I eggs at the Great Orme station on the same survey were in Apstein's stages 1-3, suggesting again that the position of spawning was largely round the Great Orme station and not as far west as the two stations off Anglesey.

It would appear therefore that spawning off the north coast of Wales was very localised, with its centre within about twelve miles of the Great Orme, and only a little spawning beyond this limit. Spawning probably began about mid-January and was still active on March 23rd, with every indication of continuing.

(e) ISLE OF MAN—CUMBERLAND

Past observations (Scott 1913, 1914 and 1915) had established that plaice eggs occurred in many parts of the north-eastern Irish Sea, including both the waters around the Isle of Man and those between the Isle of Man and the coasts of Cumberland and Lancashire. The positions of spawning, however, were not clearly defined, nor was it evident which were the more important areas, except that more eggs had been obtained between the northern end of the Isle of Man and Cumberland, and round Port Erin, than elsewhere. The importance of the former of these two areas was confirmed by the catching of spawning plaice (Johnstone *et al.*, 1922), but there was the probability that the numbers of plaice eggs caught off Port Erin were high due to the more intensive sampling done there.

The 1953 surveys confirmed the presence of plaice eggs over much of the north-eastern part of the Irish Sea. Eggs less than 5 days old were found on one or more surveys at most stations worked to the north-east, east and south-east of the Isle of Man, with the largest numbers occurring some 10 miles west of St. Bees Head in the same area found by Johnstone, and at a second position some 10-20 miles south-east of Douglas, I.O.M. A few young eggs were also found along the west and north coasts of the Isle of Man, suggesting that a little spawning had been occurring practically all round the Island.

The fact that the number of young eggs present in this area on the last survey (Mar. 23rd-25th) was equal to those on the previous survey suggests that spawning was likely to have continued for several weeks, well into April. This agrees with Scott's findings that plaice eggs were present off Port Erin until about Apr. 23rd, in several years.

(f) COAST OF IRELAND

On the first and third surveys, stations were worked along much of the south and east coasts of Ireland. Small numbers of plaice eggs were found at several points and the positions of the group I and groups IV+V eggs are shown on Figs. 1 and 3.

It would appear that a little spawning occurs at a number of points. The largest number of eggs was found on the most south-westerly station (station 31) on the third survey, and these included eggs at all stages of development. The weather was becoming bad when these westerly stations were being worked and it was not practicable at the time to extend the survey further west into the more exposed waters. Owing to the drift of the ship at this station, the catch was at least 50% greater than it would have been in calm conditions. However, the presence of group IV and V eggs at the next two stations along the coast to the east support the findings at station 31 and suggest that to the west of this point is the main spawning area of the plaice living along the south coast of Ireland.

(g) DISCUSSION

In Fig. 5, the positions where group I plaice eggs were found on any of the four surveys are put together on one chart by showing the outer limits of the I group contours (1 egg

per 3 hauls) when Figs. 1-4 are superimposed on each other. The areas where most group I eggs were found are also indicated.

Looking at the spawning areas as a whole, it is seen that they are typically coastal rather than offshore, though the depth of water in which young eggs were found varied between 8-10 fathoms in Cardigan Bay, and 39 fathoms off the north coast of Cornwall. When related to the salinity and temperature of the water (Bowden, 1955; Lee, in preparation), it is immediately apparent that, in contrast to the Southern Bight of the North Sea, there is no positive correlation between the areas of spawning and water of high temperature and salinity.

While there appears to be an indication of spawning in the Irish Sea being a little earlier in the south than the north, spawning in the Irish Sea as a whole was four to six weeks later than is typical of the Southern Bight of the North Sea, where the latitude of the centre of spawning is a little south of that of the Cardigan Bay spawning area. ($52^{\circ} 0'N$. compared with $52^{\circ} 25'N$.).

In the southern North Sea, the plaice spawn from mid-December to early March, during the period of declining water temperatures, the minimum sea temperature typically occurring in the Southern Bight spawning area in March.

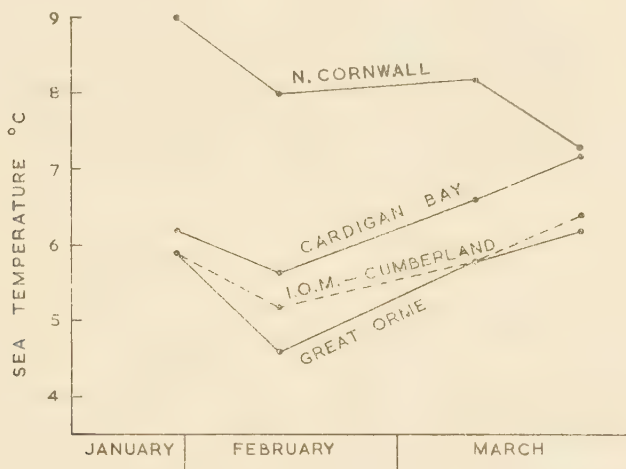


Fig. 6. *Surface sea-water temperatures in each of the four main spawning areas.*

In Fig. 6, the water temperatures in the four main spawning areas in the Irish Sea during the period of the investigations are shown. The temperatures used in this diagram are the means of the surface water temperatures at stations where group I eggs were found, weighted by the number of group I eggs at each station.

From these observations in 1953 and the mean monthly values given by Bowden (1955, Table 1), it is apparent that, in the shallower areas of the Irish Sea, the minimum temperatures are reached in mid or late February with the result that most of the spawning is occurring during rising temperatures.

In the deeper water, typified by the SEVEN STONES L.V. observations from Bowden's data, the minimum water temperatures were reached in early to mid-March which, with the 1953 observations from north Cornwall, suggests that the minimum water temperatures probably occur about half-way through the spawning period in that area.

It is not possible from these surveys to make an accurate assessment of the total number of eggs spawned annually by the plaice in the Irish Sea, due to the small numbers of eggs in the samples and to the fact that the surveys did not cover the later part of the spawning. However, by using the same methods as those used for the North Sea calculations (Simpson, 1959, Section II), it is possible to make an estimate of the order of magnitude of the egg production in the Irish Sea in 1953.

By measuring the areas of sea enclosed by the various contour lines in Figs. 1-4, the total number of group I eggs present at the time of each survey has been calculated for all areas together. Dividing these figures by the time in days for a plaice egg to develop through the stages covered by group I, the following estimates of daily egg production have been obtained:

<i>Survey</i>	<i>No. of Eggs per day</i>
1.	0.06×10^{10}
2.	0.25×10^{10}
3.	0.27×10^{10}
4.	0.26×10^{10}

These figures are approximately half the daily egg production found for the Flamborough spawning area of the North Sea in 1949, when the annual egg production for that area was estimated at 0.39×10^{12} eggs. This would suggest that annual egg production in the Irish Sea in 1953 was of the order of 0.2×10^{12} eggs.

The annual egg production in the Southern Bight of the North Sea was found to have settled down after the war period to a level of approximately 3.5×10^{12} (Simpson, 1959). Therefore the number of eggs laid in the Irish Sea in 1953 was probably about 1/18th of that in the Southern Bight or 1/40th of that in the North Sea as a whole.

In a separate account of the fecundity of the Irish Sea plaice (Simpson, in preparation), it has been estimated that the average number of eggs laid per plaice in 1953 was approximately 67,000. Taking the Irish Sea egg production to have been in the region of 0.2×10^{12} , the number of females taking part in the spawning will have been about 3 million.

III. THE DRIFT OF THE EGGS

LITTLE information on local water movements in the areas of spawning can be deduced from the salinity data obtained on the 1953 surveys. However, some pointers as to the direction in which the eggs were being drifted, and therefore presumably the larvae also, can be got from a comparison of the distribution of the old eggs (groups IV and V) with the areas of spawning, as derived from the distribution of group I eggs.

Off the north coast of Cornwall, the distribution of group IV and V eggs followed very closely the distribution of group I eggs, indicating no residual water movement.

In Cardigan Bay, the older eggs were consistently found to the south of the centre of group I eggs on the same and the previous surveys, suggesting that in February and March, there was a residual drift to the south along the coast in Cardigan Bay, presumably due to an induced clockwise eddy in the Bay. There is no evidence of any eggs in 1953 being drifted to the north, from Cardigan Bay into Caernarvon Bay.

Off the Great Orme, there is little evidence of a definite movement in any direction, though the fact that group IV and V eggs on the last survey were found to the west of younger eggs on the same or the previous surveys, suggests that here again there may be a clockwise eddy.

To the south-east of the Isle of Man, the distribution of young and old eggs is too diffuse to permit any deductions relating to the drift of the eggs.

Off the Solway Firth on the last two surveys, small but definite concentrations of young eggs were found at the same station some eleven miles west of St. Bees Head, with no young eggs at the stations immediately to the west and north-west of this station. There were however older eggs at these stations to the west and north-west, suggesting a residual movement of the water to the west between the Isle of Man and Scotland.

On the Irish coast, the numbers of eggs caught were very small but off the south coast on the third survey, the older eggs were found extending considerably further east along the

coast than the group I eggs, which were limited to the most westerly station worked, thus suggesting an easterly coastal drift.

It is appreciated that the numbers of eggs available for this study of the drift are too few to draw very firm conclusions; but, in the absence of other data and in view of the importance of the subject, it is considered worth while to set out these observations.

IV. AGE AND SIZE-COMPOSITION OF THE SPAWNING FISH

TRAWLING was carried out on the second and fourth surveys in each of the areas which had been determined as spawning areas from the observed distribution of the young eggs. The aims of the trawling were to confirm the existence of the spawning areas by catching spawning plaice, to obtain ovaries of spawning plaice for a determination of the fecundity of the Irish Sea plaice and to obtain information on the age and length-composition of the spawning fish.

A standard Granton otter-trawl with a 60mm mesh cod-end and wooden bobbins was used for the trawl sampling. The heavy bobbins were used as a precaution against seriously damaging the gear on unfamiliar fishing grounds.

The lengths of all plaice caught were recorded and the otoliths were removed for age-determination from all mature females and from all other plaice with the exception of both the immature fish and the mature males off Gt. Orme's Head and Cardigan Bay on the fourth survey. Details of sex, age and length of the mature fish are given in Appendix II.

The presence of spawning plaice in the catches and the high male/female sex-ratios among the mature fish confirmed that each area trawled was a spawning area (see Table 3).

Table 3: *Sex-ratios of the total catch of plaice, and of the mature plaice, from the four spawning areas*

Area	All plaice		Mature plaice only	
	Male/Female	No. caught	Male/Female	No. caught
Cumberland	3.7	337	6.4	285
Great Orme	8.9	1,110	10.4	1,091
Cardigan Bay	3.4	1,319	7.0	967
Cornwall	2.5	67	6.9	55

The percentage age-compositions of the mature plaice in the four spawning areas are shown in Fig. 7.

Although observations from a single year can be misleading, it would appear probable from a comparison with research ship samples from the North Sea spawning areas (Simpson 1959, Fig. 40) that the Irish Sea stock or stocks in 1953 contained considerably fewer of the older fish, proportionally, than the stock spawning in the southern North Sea.

In 1950, over 30% of the females spawning in the southern North Sea were in age-groups above V and 25% of the males were in age-groups above IV, compared with less than 10% and 2% respectively in the Irish Sea in 1953. Even when the fish below 25 cm are omitted for comparison with commercial landings and the data from the three more northerly spawning areas are added together, as has been done in Fig. 8, the II-group plaice are still the most abundant among the males and the III-group among the females.

The large proportion of group I males in the sample of mature plaice obtained off the north Cornwall coast is worth noting, although the sample was very small (Appendix II, Table 7).

Turning to the length-composition of the mature fish (Fig. 9), it is seen that the average size of the plaice spawning in Cardigan Bay was markedly less than that off Cumberland, the average size from the Great Orme area being intermediate. The absence of mature females below 26 cm in the Cumberland area is surprising and unlikely to be due to the small size of the sample alone.

In Table 4, the mean sizes of the mature female fish of each age-group from the three Irish Sea areas are given, where the data are adequate, and also the comparative mean sizes from the North Sea spawning areas (Simpson, 1951).

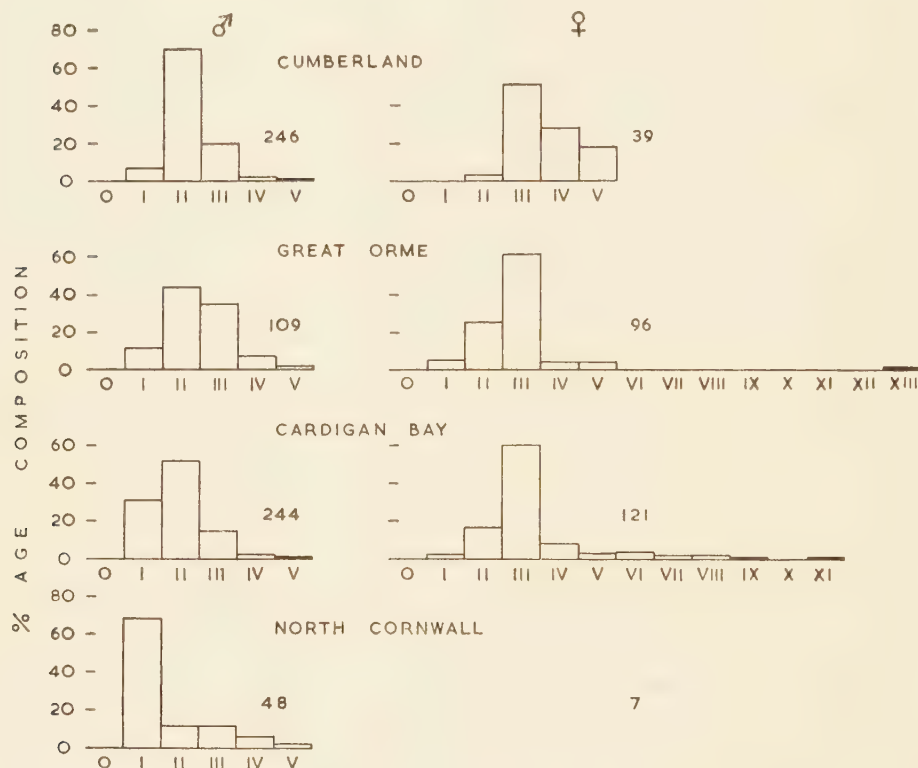


Fig. 7. Percentage age-compositions of the mature male and female plaice in each of the four spawning areas. The number of fish sampled is shown to the right of each histogram.



Fig. 8. Percentage age-compositions of the mature male and female plaice above 25 cm in length for the Cumberland, Great Orme and Cardigan Bay areas combined.

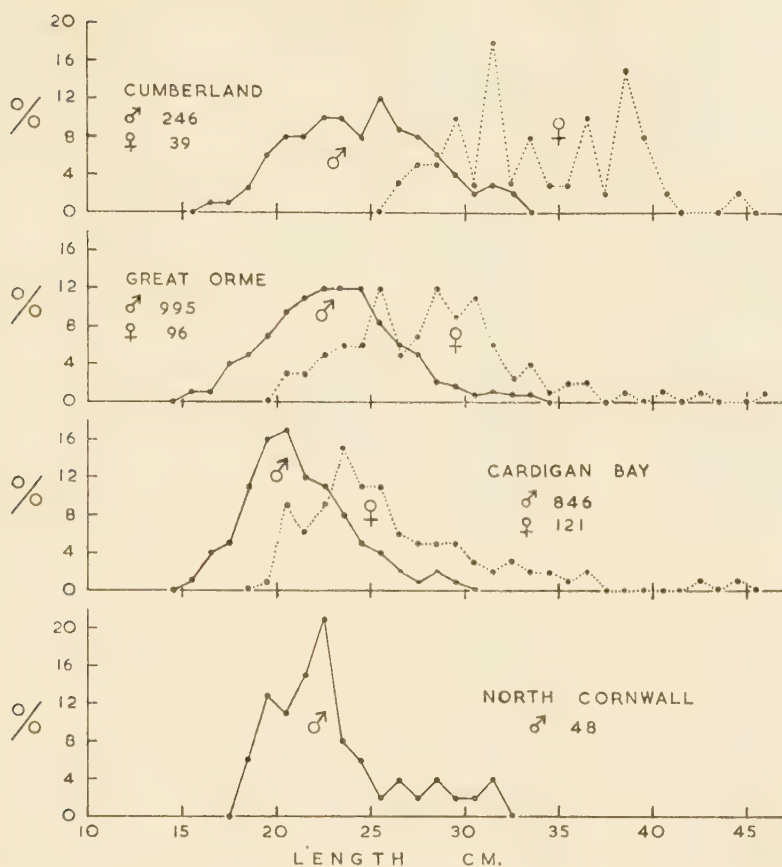


Fig. 9. Percentage length-compositions of the mature male and female plaice in each of the four spawning areas.

Table 4: The mean lengths of mature female plaice, by age-groups, taken in the spawning areas in January to March. The number of fish in each sample is given in brackets

Area	Age-Group				
	I	II	III	IV	V
Cumberland, 1953	—	—	32.6 (20)	33.8 (11)	39.1 (7)
Flamborough, 1949	—	—	31.1 (17)	33.9 (25)	37.1 (20)
Great Orme, 1953	21.5 (5)	26.2 (24)	28.8 (58)	34.8 (4)	31.5 (4)
Southern Bight, 1949	—	24.5 (6)	26.6 (124)	29.5 (56)	31.7 (45)
Cardigan Bay, 1953	20.0 (2)	23.6 (20)	25.4 (72)	25.0 (10)	27.0 (4)

Taking the Irish Sea data first, although the number of fish available for comparison is small, it would seem justifiable to conclude that there was definitely a difference in the size of mature plaice of the same age in the three spawning areas, with the larger fish being found in the Cumberland area, and the smallest in the Cardigan Bay area; the Great Orme area being intermediate. These differences are supported by the mean sizes of the larger numbers of mature males in each age-group obtained from the same three spawning areas (Table 5).

Table 5: *The mean lengths of mature male plaice, by age-groups, taken in the spawning areas in 1953. The number of fish in each sample is given in brackets*

Area	Age-Group			
	I	II	III	IV
Cumberland	19.4 (17)	23.8 (173)	28.0 (50)	32.9 (5)
Great Orme	20.7 (13)	23.5 (48)	25.3 (38)	28.0 (8)
Cardigan Bay	20.1 (76)	22.2 (127)	24.4 (34)	24.5 (5)

Comparing the Irish Sea and the North Sea data given in Table 4, the size-for-age of mature females was similar in the Cumberland and Flamborough areas, while the size-for-age in the Southern Bight of the North Sea was a little greater than that in Cardigan Bay.

V. SUMMARY

1. By means of successive fish-egg surveys, the main spawning areas of the plaice in the Irish Sea were located off the north coast of Cornwall, in Cardigan Bay, off Great Orme's Head (N. Wales) and between the Isle of Man and the coast of Cumberland. Small numbers of plaice eggs were also found at several points along the coast of Ireland and in Caernarvon Bay.
2. Spawning was found to have recently started in all areas by the end of January and was still continuing actively at the end of March.
3. Estimates have been made of the number of plaice eggs laid in the Irish Sea in 1953 and the number of females that had taken part in the spawning.
4. The relative distributions of old and young plaice eggs indicated the presence of a clockwise eddy in Cardigan Bay.
5. Samples of mature plaice from the spawning areas showed the males to be largely group II and III fish with a considerable proportion of group I males in Cardigan Bay and off Cornwall, and the females to be largely group II, III and IV fish with a greater proportion of older fish in the north than the south.

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APPENDIX I

DETAILS of all plankton stations where plaice eggs were found. The positions of all stations worked are shown on Figs. 1-4.

Table 1: 1st survey. Jan. 23-Feb. 3, 1953

Day	Stn.	Position				Depth of Water (fm)	Wind	Sea	Time	Depth Filtered (fm)	Catch per 3 hauls				
		° N	,	° W	,						I	II	III	IV	V
Jan.															
23	3	50	31	05	15	27	3	3	2248	25	1	2	-	-	-
25	21	52	00	07	07	28	4	4	0630	26	-	-	-	1	-
25	22	51	56½	07	29	26	2	2	0830	24	1	-	-	-	-
26	39	52	20	04	34	15	4	4	1345	13	9	1	8	1	1
26	40	52	23	04	15	9	4	4	1512	6½	2	7	1	-	-
26	41	52	33	04	23	12	4	4	1627	10	1	-	-	-	-
Feb.															
1	57	54	23½	03	48	19	4	3	2228	16½	2	-	-	-	-
2	69	54	14	04	45	11	3	3	1405	10	1	-	-	-	-
2	75	53	26	04	11	18	4	4	2250	15	-	1	1	-	-
3	76	53	25½	03	52	16	4/5	5	0019	14	9	1	1	-	-
3	82	54	04	04	10	20	3	3	0950	18	3	-	-	-	-
3	83	54	04	03	50	24	3	3	1120	21	-	1	1	-	-
3	86	53	52	03	45½	20	2	2	1200	18	1	-	-	-	-

Table 2: 2nd survey. Feb. 9-17, 1953

Day	Stn.	Position				Depth of Water (fm)	Wind	Sea	Time	Depth Filtered (fm)	Catch per 3 hauls				
		° N	,	° W	,						Egg Stages				
											I	II	III	IV	V
Feb.															
10	3	54	04	03	50	24	4/5	4/5	0021	22	4	-	1	-	-
13	18	54	30	03	57	21	5	5	0110	18	1	-	-	-	-
13	20	54	24	04	05	14	5	5	0344	11	4	1	1	-	-
13	21	54	15	03	46	17	5	5	0525	15	1	-	-	-	-
13	22	54	15	04	00	10	4	4	0650	8	-	2	2	-	-
13	23	54	14½	04	14	14	4	4	0837	12	-	-	1	-	-
13	24	54	04	04	10	23	4	4	1023	23	-	1	-	-	1
13	28	53	52	03	46	18	3	3	1652	15½	1	-	2	-	-
14	34	53	25½	03	52	14	3	3	0405	12	3	-	-	-	-
14	36	53	26	04	11	21	3	3	1025	18½	2	2	-	-	-
14	37	53	33	04	07	26	3	3	1142	18½	-	1	1	1	2
14	40	53	30	04	28	22	2	3	1547	20	1	2	1	-	-
14	41	53	28	04	47	23	2	3	1708	21	-	-	1	-	-
15	51	52	33	04	23	12	2	2	0717	10	1	-	-	-	-
15	52	52	23	04	15	8	2	2	0842	7	17	5	5	1	-
15	55	52	17	04	35½	14	1	1	1412	9	10	1	4	-	-
15	57	52	13½	04	34	12	0	0	1735	10	6	5	7	1	2
15	59	52	20	04	24	12	0	0	2050	10	19	7	8	1	-
15	60	52	26	04	29	15	0	0	2147	13	15	-	-	-	-
15	61	52	28	04	41½	20	2	2	2305	17	6	-	-	-	-
16	62	52	27½	04	52½	30	2	2	0007	28	3	-	-	-	-
16	63	52	22	04	47	20	2	2	0127	17	2	1	-	-	-
16	64	52	15	04	56½	24	3	3	0235	22	-	2	-	-	-
16	65	52	12	04	45	18	2	3	0348	16	5	15	23	10	1
16	66	52	07½	04	55½	21	2	3	0450	19	1	3	6	2	1
16	67	52	02½	05	09	25	2	2	0614	23	1	1	-	-	-
16	73	50	42½	05	10½	33	2	2	2225	31	1	1	2	2	-
17	74	50	45½	05	28	36	2	2	0003	33	5	4	6	6	12
17	76	50	37	05	44	36	2	2	0337	33	-	-	1	-	-
17	77	50	32	05	30½	32	2	2	0508	30	32	28	26	13	22
17	78	50	28½	05	18	23	2	2	0642	21	5	-	4	1	1
17	79	50	19	05	32	19	3	2	0845	17	2	3	-	-	-

Table 3: 3rd survey. March 7-14, 1953

Day	Stn.	Position				Depth of Water (fm)	Wind	Sea	Time	Depth Filtered (fm)	Catch per 3 hauls				
		° N	° W	Egg Stages											
				I	II						III	IV	V		
Mar.															
7	4	50	23 05	17½	19	3	3	1502	17	2	3	4	-	-	
7	7	50	54 05 05	33	2	2	2039	31	1	1	1	-	-		
7	8	50	41½ 05 18	34	2	2	2240	32	14	6	7	6	2		
8	9	50	29 05 32	32	2	2	0040	30	1	1	-	-	-		
8	11	50	48 05 33	39	4	4	0445	36	1	1	-	-	1		
8	14	51	06 04 51	33	2	2	1055	31	5	-	1	-	-		
9	24	51	56½ 06 35	29	2	2	0508	27	1	-	-	-	-		
9	29	51	49 07 49	28	3	3	1313	26½	-	-	-	-	3		
9	30	51	43 08 11½	26	3	3	1512	24	-	-	-	-	3		
9	31	51	39½ 08 24	21	3	3	1650	18½	4	4	2	1	4		
10	41	52	07½ 04 55	21	2	2	1255	18½	1	-	3	1	2		
10	42	52	12 04 42	16	1	1	1407	13½	3	-	-	3	1		
10	43	52	17 04 29	12	1	1	1524	10	3	1	-	-	-		
10	44	52	22 04 15	8	0	0	1641	6	16	2	-	-	-		
10	45	52	30 04 22½	9	1	0	1749	7	3	-	-	-	-		
10	46	52	25 04 36	15	2	2	1912	12½	8	-	2	-	-		
10	47	52	20 04 49	22	2	2	2007	20	3	1	-	-	-		
11	50	52	33 04 43	20	2	2	0112	18	1	-	-	-	-		
11	51	52	37½ 04 31	12	2	2	0230	10	1	2	-	-	-		
11	55	53	07 04 35	13	3	3	0850	11	10	1	-	-	-		
11	62	53	22 04 01	11	1	1	1812	9	1	-	2	-	-		
11	63	53	25½ 03 52	15	1	1	1906	12½	22	2	4	1	2		
11	64	53	28½ 03 31½	12	1	1	2036	10	22	12	9	2	-		
11	65	53	28 03 22	9	1	1	2130	7	1	8	3	-	-		
11	66	53	37½ 03 26	14	3	3	2251	12	-	1	-	-	-		
12	67	53	34½ 03 44	20	3	3	0012	18	2	-	2	2	-		
12	68	53	33 03 58½	23	3	3	0125	21	7	1	-	1	-		
12	71	53	51 03 48	21	2	2	0612	18	4	1	-	-	-		
12	72	53	52 03 25	10	2	2	0750	8	-	-	-	-	2		
12	73	54	04 03 31	14	3	3	0930	12	1	-	-	2	1		
12	74	54	04 03 50	25	2	2	1057	23	4	3	1	-	1		
12	75	54	04 04 10	20	2	2	1232	17½	4	2	1	-	-		
12	76	54	07 04 22½	16	2	2	1339	14	2	1	-	-	-		

Table 3: 3rd survey. March 7-14, 1953 (continued)

Day	Stn.	Position				Depth of Water (fm)	Wind	Sea	Time	Depth Filtered (fm)	Catch per 3 hauls				
		° N	'	° W	'						I	Egg II	Stages III	IV	V
Mar.															
12	77	54	14½	04	13½	12	2	2	1500	10	1	2	1	5	3
12	78	54	14½	04	00	9	2	2	1602	7	2	-	1	1	1
12	79	54	14½	03	46	16	2	2	1704	14	-	-	-	-	1
12	80	54	14½	03	31	11	0	0	1812	9	-	-	-	1	-
12	82	54	23½	03	51	22	1	1	2044	20	2	-	-	1	1
12	84	54	30	03	56	21	1	1	2319	19	11	-	-	1	-
13	86	54	37½	03	52	14	1	1	0132	12	1	-	-	-	-
13	88	54	37½	04	13	28	1	1	0315	26	-	1	-	1	-
13	89	54	31	04	14½	20	1	1	0425	18	-	-	-	1	-
13	90	54	27	04	28	20	1	1	0601	18	-	-	1	-	-
13	94	54	14	04	45	12	0	0	1101	10	-	1	-	-	-
13	95	54	05	04	48	17	1	0	1208	14	-	1	-	-	-
13	96	54	06½	04	57½	32	1	0	1301	30	1	-	-	-	-
13	100	54	10½	05	45	11	2	2	1725	9	4	-	-	-	-
13	101	54	01½	05	52	17	2	2	1843	15	-	-	-	-	1
14	108	53	37½	06	01	14	3	2	0704	13	1	-	-	-	-
14	110	53	26½	05	56	14	3	3	0934	11½	-	3	1	-	-

Table 4: 4th survey. March 20-28, 1953

Day	Stn.	Position				Depth of Water (fm)	Wind	Sea	Time	Depth Filtered (fm)	Catch per 3 hauls				
		° N	,	° W	,						Egg stages				
											I	II	III	IV	V
Mar.															
21	14	52	20	04	49	20	1	1	0523	18	21	18	8	3	-
21	16	52	02½	05	07	25	1	1	0828	23	-	-	-	1	1
21	17	52	07	04	55	21	1	1	0943	17	-	4	14	9	2
21	18	52	12	04	42	17	1	1	1105	14½	3	6	6	2	-
21	20	52	17	04	29	12	2	2	1622	10	4	-	-	-	-
21	22	52	21½	04	19	9	1	1	1951	5½	-	1	-	-	-
22	24	52	25	04	36	15	1	1	0002	12½	9	4	2	1	1
22	25	52	30	04	22	12	3	3	0120	10	4	-	-	2	-
22	26	52	38	04	30	12	3	3	0239	10	3	-	-	-	-
22	27	52	33	04	43	18	2	2	0400	15½	22	23	4	-	-
22	30	53	01	04	32	12	0	0	0958	10	-	1	1	-	-
22	35	53	29½	04	29	25	1	1	1616	23½	-	-	1	-	-
22	36	53	26	04	11	20	1	1	1800	18	-	15	18	5	2
22	38	53	26	03	54	13	1	1	2214	11½	42	14	-	2	1
23	39	53	28½	03	32	11	0	0	0058	9½	1	-	-	-	-
23	40	53	37½	03	26	15	0	0	0234	13	-	-	-	1	-
23	41	53	35	03	46	21	0	0	0425	17½	6	5	3	2	-
23	45	53	52	04	07	23	2	2	1120	21	3	-	-	-	-
23	49	54	04	03	50	24	0	0	1807	20	3	4	2	1	-
23	50	54	04	04	10	20	1	1	1953	18	12	4	3	-	1
23	52	54	14½	04	13½	15	2	2	2100	12½	3	4	2	-	-
24	54	54	14½	03	46	17	2	2	0118	14	-	-	-	1	1
24	55	54	14½	03	31	12	2	2	0240	10	-	-	-	3	1
24	56	54	24	03	37	12	1	1	0401	10	-	-	-	1	-
24	59	54	23½	03	51½	20	2	2	1110	17½	-	-	1	-	-
24	60	54	23½	04	07½	15	1	1	1330	12	-	-	1	-	-
24	61	54	30	03	56½	21	0	0	1645	18½	6	-	2	2	1
24	63	54	36	03	57	18	2	2	2027	-	1	3	5	1	2
25	64	54	37	04	02½	21	0	0	0210	18½	-	-	2	1	-
25	65	54	38	04	13	31	1	1	0942	29	-	-	-	-	1
25	66	54	31	04	15	21	1	1	1105	17½	-	-	2	1	-
25	67	54	27	04	28	18	1	1	1230	16½	1	-	1	1	-
25	68	54	28	04	40	23	2	2	1343	-	-	-	-	1	-

Table 4: 4th survey. March 20-28, 1953 (continued)

Day	Stn.	Position				Depth of Water (fm)	Wind	Sea	Time	Depth Filtered (fm)	Catch per 3 hauls				
		° N	,	° W	,						Egg stages				
											I	II	III	IV	V
Mar.															
25	70	54	13½	04	45	12	3	4	1618	9½	2	2	-	-	-
25	75	53	52	04	55	40	4	4	2222	37	-	-	1	1	-
26	79	52	40	05	13	52	5	6	1001	44	-	-	1	1	-
26	84	51	13	05	06	35	2	3	2147	32½	6	1	1	-	-
26	85	51	01	05	20	39	2	3	2357	37½	-	-	1	-	1
27	86	50	54	05	05	33	2	2	0145	29	-	-	-	1	1
27	87	51	06	04	51	33	2	2	0348	31	6	3	1	1	1
27	88	51	21	04	42	25	2	2	0600	23	1	-	-	1	1
27	90	51	00½	04	38	22	1	2	0953	18	-	1	-	-	-
27	91	50	47	04	49	24	2	3	1147	21½	1	-	-	-	-
28	98	50	41	05	18	34	5	5	0300	30	-	1	1	1	4

APPENDIX II

Age-length compositions of the mature plaice from the spawning areas

Table 1: *Cumberland, Feb. 10, 1953*
Stn. 9 *54° 22½' N. 3° 49½' W.*
10 *54° 25' N. 3° 56' W.*
Depth (fm) 20-23
22

Age-Group	Sex	Length (cm)										Total	
		14	15	20	25	30	35	40	45	M	F		
I	M F		2 1 4 1	4 1 - 1 1						15	-		
II	M F		2 10	11 11 14 17 11	21 10 7 6 3	2 1				125	1		
III	M F			1 2 2	5 4 12 6 2 1 1 1	2 5 4 - 5 1 1	- 3 - 2 1			45	16		
IV	M F				1 2	- - 1 1 1 - - 2 -	- - 1 1			3	7		
V	M F				1		1 1 - 1 1	1 - - - 1		1	6		

Table 2: Cumberland. Mar. 24, 1953 Stn. 62 54° 33' N. 3° 57' W Depth (fm) 18-21

Age-Group	Sex	Length (cm)										Total	
		14	15	20	25	30	35	40	45	M	F		
I	M F		1 1							2	-		
II	M F		3	5 8 10 4 5	3 6 1 - 3					48	-		
III	M F			1 -	- 1 - 1 1 1	- 1 -				5	4		
IV	M F				1 - -	1 - -	1 - -	1 1 1		2	4		
V	M F							1		-	1		

Table 3: *Great Orme, Feb. 14, 1953.* *Stn.* *Position* *Depth (fm)*

<i>Age-Group</i>	<i>Sex</i>	<i>Length (cm)</i>										<i>Total</i>	
		14	15	20	25	30	35	40	45	M	F		
I	M F		2 2 -	4 2 1 - 2						13	-		
II	M F		3	5 6 4 9 10 1 1 - 1	4 4 3 1 - - 1 1	- - - 1 1				48	6		
III	M F		1 - -	- 3 5 5 3 1 - -	4 6 6 1 3 1 - 1 2 1	- - 1 1 1 2 1 2				38	12		
IV	M F				4 - - 1 1 1	- 1 1				8	1		
V	M F				1 - - -	- - 1	1			2	1		
XIII	F								@ 50		1		
Not Aged	M		2 4 5 1 1	18 24 20 22 22	17 10 13 5 4	3 1 1 2 -	- - 1					185	

Table 4: *Great Orme, Mar. 22, 1953.* *Stn. 37* *Position 53° 26' N. 3° 58' W.* *Depth (fm) 15*

Age-Group	Sex	Length (cm)										Total	
		14	15	20	25	30	35	40	45	M	F		
I	F			3 1 - - 1									5
II	F			1 1 2 2	2 4 3 3								18
III	F			1 2 4 2	7 1 3 3 5	8 3 1 1 1	1 2 - - -	1					46
IV	F				1	- - - - -	- - - 1 -	- - - 1					3
V	F				1 -	1 1							3
Not Aged	M	1	8 6 31 42 55	68 74 86 81 82	57 39 27 16 8	4 9 3 4						701	

Table 5: Cardigan Bay. Feb. 15, 1953.

Stn. Position Depth (fm)

53 52° 22½'N. 4° 20½'W. 11-12

54 52° 19½'N. 4° 40'W. 11-14

56 52° 14½'N. 4° 36'W. 13

58 52° 16'N. 4° 29'W. 11-12

Age-Group	Sex	Length (cm)										Total	
		14	15	20	25	30	35	40	45	M	F		
I	M F		2 4 16 16	20 9 4 3 1 1	1					76	1		
II	M F		1 4 17	22 19 23 17 9	6 4 1 2 1 1	- 1				127	1		
III	M F		1	2 3 6 4 6 2 - 1 1 2	3 2 3 3 1 1 1 - 1 3	2 - 1				34	15		
IV	M F			1 - - 1 1	1 - - 1 2					5	2		
V	M F			1 - +	1					2	-		
VI	M F				1					-	1		
	F						VII @ 42	VIII @ 33			2		

Table 6: *Cardigan Bay. Mar. 21, 1953.*

Stn. Position Depth (fm)

19 52° 13' N. 4° 39½' W. 17

21 52° 18' N. 4° 26' W. 11-12

23 52° 22' N. 4° 22' W. 9-12

Age-Group	Sex	Length (cm)										Total	
		14	15	20	25	30	35	40	45	M	F		
I	F		1								1		
II	F			3 3 2 4 2	2 1 2						19		
III	F			5 5 7 10 9	5 2 4 2 1	2 1 2 - 1	1				57		
IV	F			1 2 -	3 2						8		
V	F			1 -	- 1 - 1 1						4		
VI	F				1 - 1 1	- - - - -	- - - - -	- - - - -			4		
VII	F					1 - 1	- 1				2		
	F				VIII @ 31, 32	IX @ 34	XI @ 36				4		
Not Aged	M	2	7 32 35 73 100	98 71 58 45 27	25 9 5 9 3	2 - 1					602		

